

CLAIMS

1. A liquid-mixing apparatus for producing a liquid mixture obtained by mixing two or more liquid components, a liquid mixture obtained by mixing a liquid component and a gas component, a liquid mixture obtained by mixing a liquid component and a powder component, or a combination of some of the liquid mixtures mentioned above, the liquid-mixing apparatus comprising:
 - a vessel for storing the mixture components;
 - 10 a vibrator disposed in the vessel and having at least one surface with a predetermined area contacting the mixture components;
 - a high-frequency vibration generator, connected to the vibrator, for vibrating the vibrator at high frequency in a direction perpendicular to said surface; and
 - 15 a reflector disposed in the vessel, said reflector being arranged with a space from the vibrator at a small distance so that said surface of the vibrator contacting the mixture components faces a surface of the reflector, and reflecting high-frequency vibration transmitted from the vibrator to create reflected waves in the mixture components flowing between the facing faces,
 - 20 wherein the vibrator and the reflector cooperate to create cavitation bubbles in the mixture components utilizing a decompression action of the vibrator allowed to move away from the reflector by the high-frequency vibration transmitted from the high-frequency vibration generator to the vibrator and also cooperate to break the cavitation bubbles utilizing the compression action of the vibrator allowed to move toward the reflector, and

- shock wave energy generated by the breaking action extremely reduces the size of the cavitation bubbles and promotes the diffusion of the mixture components, so that the liquid mixture is allowed to have an ultra fine particle size and high density.

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2. The liquid-mixing apparatus according to claim 1, wherein the high-frequency vibration transmitted from the high-frequency vibration generator to the vibrator has an ultrasonic frequency.

10 3. The liquid-mixing apparatus according to claim 1, wherein the vibrator creates the cavitation bubbles in the mixture components and then breaks the cavitation bubbles repeatedly.

15 4. The liquid-mixing apparatus according to claim 1, wherein the high-frequency vibration generator includes a ceramic piezoelectric vibrating member or a vibrating member composed of a super magnetostRICTive material or a magnetostRICTive material and the vibrator is provided with the reflector or connected to the reflector with a space present therebetween.

20 5. The liquid-mixing apparatus according to claim 1, wherein the vibrator has a surface section, and the reflector has a surface section facing the surface section of the vibrator, and at least one of these surface sections contains a hard material resistant to cavitation damage caused by the cavitation bubbles.

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6. The liquid-mixing apparatus according to claim 1, wherein the

reflector is detachably attached to the vessel.

7. The liquid-mixing apparatus according to claim 1, wherein the distance between the vibrator and the reflector is 10 mm or less.

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8. The liquid-mixing apparatus according to claim 1, wherein the vessel has a mixture component inlet through which the mixture components are fed to a space between the vibrator and the reflector and has a liquid mixture outlet through which a liquid mixture, treated between the vibrator and the reflector with shock waves, having a fine particle size, is discharged outward.

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9. The liquid-mixing apparatus according to claim 1, wherein the vessel has one or more perforations which extend through a center area of the reflector and through which the mixture components are fed to a space between the vibrator and the reflector.

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10. The liquid-mixing apparatus according to claim 1, wherein at least one of a surface of the vibrator that faces the reflector and a surface of the reflector that faces the vibrator has a large number of cone-shaped pits for generating shock waves, the shock waves generated in the pits are converged on focal sections existing between the vibrator and the reflector, and the focal sections form an ultra strong shock wave-generating zone existing between the vibrator and the reflector.

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25 11. The liquid-mixing apparatus according to claim 1, further comprising

a plurality of vibrators, arranged in the vibration direction, facing one another, wherein the vibrators adjacent to each other function as reflectors.

12. The liquid-mixing apparatus according to claim 11, wherein the
5 vibrators have channels, extending therethrough, for allowing the mixture components to move in a meandering fashion.

13. A liquid-mixing method of producing a liquid mixture obtained by mixing two or more liquid components, a liquid mixture obtained by mixing
10 a liquid component and a gas component, a liquid mixture obtained by mixing a liquid component and a powder component, or a combination of some of the liquid mixtures mentioned above, the liquid-mixing method comprising the steps of:

15 storing the mixture components in a vessel including a vibrator
vibrating at high frequency and a reflector spaced from the vibrator at a
small distance;

20 creating cavitation bubbles in the mixture components flowing between the vibrator and the reflector utilizing a decompression action of the vibrator allowed to move away from the reflector by high-frequency vibration transmitted from the high-frequency vibration generator to the vibrator;

breaking the cavitation bubbles utilizing the compression action of the vibrator allowed to move toward the reflector;

reducing the size of the cavitation bubbles with shock wave energy generated due to the compression action; and

25 promoting the diffusion of the mixture components to allow the liquid mixture to have an ultra fine particle size and high density.

14. The liquid-mixing method according to claim 13, wherein when two or
more liquid components are used, in which one of the liquid components is
a fuel oil, a gas oil, a waste oil, or a waste edible oil and another one is at
5 least one selected from the group consisting of an oil other than the above oil,
alcohol, a solvent other than alcohol, and water, said components being
mixed into an liquid fuel.

15. The liquid-mixing method according to claim 13, wherein when a
10 liquid component and a gas component are used, the liquid component is an
edible oil or an fatty oil which contains at least one of a liquid additive and a
liquid perfume and the gas component is air, said components being mixed
into a creamy food product, a cosmetic product, or a drug product.

15 16. The liquid-mixing method according to claim 13, wherein when a
liquid component and a powder component are used, the liquid component
is an industrial ingredient, a food ingredient, a cosmetic ingredient, or a
drug ingredient, and the powder component is a fine ceramic powder, a fine
food powder, a fine cosmetic powder, or a fine drug powder which contains
20 an additive, said components being mixed into an industrial liquid material,
a food product, a cosmetic product, or a drug product.